UPDATE ON HYDRAULIC FLUIDS DEVELOPMENT
SUBSEA CONTROLS DOWNUNDER 2018

Simon McManus
Continued Development

- I am an Engineer and work with PhD Chemists
- I tell them what the industry needs
- They make it
- They tell me how it works
- I try to understand
- Then my team and I test it
- I feel like Howard in the Big Bang Theory most of the time
Anatomy of a control system

- Hydraulic fluid can be thought of as the blood of a control system.
- Transferring energy to the functional components
- Fluid maintenance built in
- Condition monitoring for diagnostics are essential
- More closed systems are being proposed
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Hi-Tech Future Fluid Developments

- Long-term stability is paramount
  - Separation
  - Thermal degradation
  - Chemical compatibility

- Efficient energy transfer without damaging the system
  - Viscosity
  - Density
  - Bulk Modulus

- Recyclability in closed systems
  - Solid contamination removal
  - Liquid contamination removal/tolerance

- Environmental efficiency in open systems
Environmental Future

- **Standard Tests**
  - Biodegradation, toxicity, bioaccumulation
- **Contradictions in long term stability and environmental persistence**
- **Introduction of Health and Safety elements**
  - New substitution warnings due to updated assessment methods
- **Exposure and degradation methods**
- **Degradation Oxygen Demand**
  - High biodegradation rates are not always a good thing!
ISO 13628-6 migration to API 17F

- Updates to make procedures clearer and more defined.
- API 17F is not a qualification (pass/fail) procedure
  - API 17F produces an information document highlighting limitations and capabilities of the hydraulic fluid
  - Can be used as a starting point for specific project requirements
- Defined visuals for hydraulic fluid degradation
- Distinct procedures for aqueous and non-aqueous fluids
- Fluid compatibility testing continues to examine longer term system impact.
  - If solids are formed what happens if this travels into other parts of the system
- New Nickel plating test.
### API 17F Fluid and Solid Standard Description

<table>
<thead>
<tr>
<th>Liquid Descriptors</th>
<th>Solid Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Clear</td>
<td>A No Solids</td>
</tr>
<tr>
<td>2 Slight Haze</td>
<td>B Very slight mobile deposit &lt;2%</td>
</tr>
<tr>
<td>3 Hazy</td>
<td>C Mobile Solid Deposit 2-10%</td>
</tr>
<tr>
<td>4 Opaque</td>
<td>D Mobile Solid Deposit &gt;10%</td>
</tr>
<tr>
<td></td>
<td>E Very slight non-mobile deposit &lt;2%</td>
</tr>
<tr>
<td></td>
<td>F Non-mobile solid deposit 2-10%</td>
</tr>
<tr>
<td></td>
<td>G Non-mobile solid deposit &gt;10%</td>
</tr>
</tbody>
</table>

Additional comments and photographs should be used to supplement the descriptor.
NEW API 17F TEST – NICKEL COATING COMPATIBILITY

- Specified by OEMs following build up of sticky residues on solenoids
- Test method same as metals
- Maximum Spacing 25 microns between Electroless nickel pieces
- Low Volume test (3 Surface Area : 1 Fluid Volume)
Chemical Oxygen Demand

- 1 litre of MEG
- Will deplete all the Oxygen in 78,000 litres of seawater during degradation
### COD Reduction

**Table I – COD Values for Freeze Protection Additives & Formulated Fluids**

In-house COD testing (Table I) show that an 85% reduction in COD can be achieved by adopting a Glycol Free formate salt based fluid.

<table>
<thead>
<tr>
<th>COD (mg/l)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeze Protection additive MEG</td>
<td>1566000</td>
</tr>
<tr>
<td>Formate</td>
<td>264500</td>
</tr>
<tr>
<td>Fully Formulated Fluid MEG</td>
<td>870000</td>
</tr>
<tr>
<td>Formate</td>
<td>126000</td>
</tr>
</tbody>
</table>
# Physical Properties

<table>
<thead>
<tr>
<th>Oceanic OFF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Clear pale straw liquid</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>9.2</td>
</tr>
<tr>
<td><strong>Specific Gravity @15.6°C</strong></td>
<td>1.28</td>
</tr>
<tr>
<td><strong>Kinematic Viscosity (cSt)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>-40°C (-40°F)</strong></td>
<td>29.1</td>
</tr>
<tr>
<td><strong>-20°C (-4°F)</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>0°C (32°F)</strong></td>
<td>4.8</td>
</tr>
<tr>
<td><strong>20°C (68°F)</strong></td>
<td>2.7</td>
</tr>
<tr>
<td><strong>40°C (104°F)</strong></td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Pour Point</strong></td>
<td>&lt; -40°C (-40°F)</td>
</tr>
</tbody>
</table>
Hydrostatic Pressure Head

- **Foinaven**: 400-600m
  - Seawater: 61.5 BAR
  - Hydraulic Oil: 49.56 BAR, -11.94 BAR
  - Water-Glycol: 63.3 BAR, +1.8 BAR
  - Glycol Free: 87.5 BAR, +26 BAR

- **Girasol**: 1405m
  - Seawater: 144 BAR
  - Hydraulic Oil: 116 BAR, -28 BAR
  - Water-Glycol: 148 BAR, +4.2 BAR
  - Glycol Free: 205 BAR, +61 BAR
Function Testing

- DCV’s perceived as the most susceptible part of the control system.
- Three DCV types supplied for testing.
- Unusual results on the first set of tests.
- 100000 cycle DCV test has been completed
HTHP Testing

- Specific material are now specified for testing over 205°C
- Up to 205°C 316ss and 174PH are used for corrosion qualification.
- Above 205°C Inconel 625 is utilised
- All the high temperature samples are exposed for up to 6 months with an assembled crevice.
Why Testing over 205°C

- Development with Shell and FMC for Appomatox
- Originally set to 400°F (204.5°C)
- Fluid needed API qualification to 214.5°C with safety margin. (MacDermid ran 220°C)
- New HTHP equipment also needed development and qualification.
- Oceanic XT900 aqueous hydraulic fluid was fully qualified and the project is installed.

6 months @ 220°C
Failure at 247°C over 6 months

- **Drive to Failure @ 247 °C**
  - Tested Equipment limitations
  - Tested Metallurgical limitations
  - Tested Fluid limitations
  - Tested Technicians

- **Failure at 6 month duration**
  - Separation of fluid components
  - Able to predict failure mode
Hydrate Resistance Testing

Pressure vs Temperature diagram showing:
- High Risk area
- Low Risk area
- No Risk area

Snowflakes represent hydrate formation zones, with water droplets indicating a safe zone.

MacDermid Offshore Solutions
Hydrate Resistance and High Temperature

Methane Hydrate Dissociation Curve

Temperature C

Pressure (psi)

Oceanic HW460
Oceanic XT900
Oceanic HW443
Water
Oceanic HW740R
Oceanic XW1000
Oceanic HW 760R
And if Electric Trees Take Off?
Thank you

I hope you found it interesting